Alpaca Fibre Processing Methodology

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1. Summary

Alpaca fibre has potential uses in the textile and fashion industries as a luxurious fibre for high-end garments. For such applications, the alpaca fleece first needs to be processed to produce a clean, high quality, uniformly fine fibre for products such as roving and yarn. Prior to mechanically processing in the mills, the fleeces were cleaned, washed and dried for further studies. In this applied research, alpaca fleeces were processed using modified Belfast Mini-mills fibre processing equipment. The alpaca fibre was processed to roving through a series of five machines to produce fine, clean, and uniform fibre products required for textile and related industries.

2. Introduction

Alpaca fibre is considered a rare and luxury fibre in the world textile market. Alpaca is also a dry fleece meaning it has no or negligible lanolin, which makes the fibre hypoallergenic and a very small amount of grease (Stoller 2006). Alpaca fibre is versatile due to its glossy, silky and fine nature with its diameter between 20 and 34 microns and a length of 8-12 cm that can be processed without blending with other fibres or creates interesting yarns and fabrics when blended with other fibres (Petrie 1995). Alpaca fibre is generally used for warm clothing such as sweaters, gloves, caps, socks, scarves, expensive suits, etc. (Hoffman 2003).

From reviewing the information available and talking to both alpaca breeders and mill operators, alpaca fibre has many unique and valuable characteristics that are important in the processing stage. As alpaca fibre is a keratin based protein fibre and keratin is heat and stress sensitive, it is important to consider the temperature and processing stress while handling and processing the fibre (Cao1997, Yu 2006). Alpaca fibre’s softness is comparable with silk, which is an important selling point for fibre products. Alpaca clothing is softer than wool of the same twist of yarn. (Wang 2003, Wang 2004) The softness of the alpaca fibre in contrast to that of wool is due to its smooth surface
and low friction coefficient and the bending modulus of the alpaca fibre is higher than that of wool (Yu 2006). It is difficult to fully utilize alpaca fibre due to the lack of processing facilities in Canada. Thus, very little information is available on handling, processing and blending of alpaca fibre. Most of the fibre processing industries are partially following wool processing methodology to process alpaca fibre; as a result, it is difficult to assess the degree of quality of products produced based on wool processing standards.

This part of the research project work was aimed at evaluating the processing of alpaca fibre. Previous literature work, recent research studies and interviews with alpaca owners, especially alpaca owners in Saskatchewan, formed a large aspect of the known processing procedure for alpaca fibre. Information was gathered from various groups involved in the processing of alpaca ranging from the alpaca owners to the industrial processing companies in order to understand the current situation of fibre processing.

Alpaca fibre presents a great opportunity for use in textile products. In order to create a uniform raw material that can be used in textile industrial processes, the alpaca fibre must be sorted and graded. For this study alpaca fibre was mechanically processed using a series of five modified Belfast Mini-mills machines in the University of Saskatchewan to produce roving and then at the “Twisted Sisters” commercial alpaca fibre processing mill in Alberta to produce yarn. There are no available standards specifications or any published optimal processing procedures for mechanical processing of alpaca fibre using this equipment. The processed fibre, roving and yarn were then analyzed by taking micrographs using a scanning electron microscope (SEM).

3. Objective
The objective was to determine best practices for processing the cleaned, washed and dried alpaca fleece to produce roving and yarn.
4. Materials and Methods
The alpaca fleece was collected from SABN members. To achieve the objective, the alpaca fleece was cleaned and washed with detergent, rinsed with water and dried in a dehumidification chamber. The dried fleece was processed at the University of Saskatchewan and made into roving and then processed in a commercial alpaca fibre processing mill in Alberta to make yarn from those rovings.

4.1. Mechanical Processing
The manufacturer of the mechanical processing equipment suggested that repeated processing of the alpaca fibre through the first two machines – the tumbler and picker in the series could result in a cleaner, higher grade finished product. To determine the relevance of repeated processing, while analyzing the effect on the quality of the final product roving at the University of Saskatchewan, the fibre samples were separated into four test batches from one large batch and were sent through different processes. These fibres were labeled as samples A, B, C and D. Samples A and C were put through one process (Figure 1.) while samples B and D were put through a second process shown in Figure 2.

Figure 1. Processing sequence with samples A and C

Figure 2. Processing sequence with samples B and D

As shown in the above Figures, all four washed and dried samples were first processed through the Tumbler (Figure 3). The Tumbler is a large mesh covered drum that
tumbles the fleece to remove foreign materials. The samples were tumbled for 5 minutes. If visual observation showed that in a 5-minute period, vegetation and foreign materials were not removed from the fleece, a longer time period was required to have significant effect on the final fibre quality. It was observed that tumbling time depended on the cleanness, quantity and fineness of the fleece. 5 to 45 minutes tumbling was enough for preliminary cleaning of the fleece.

After tumbling the fleece, samples were put through the Picker. The Picker is also referred to as the opener because it begins to open and separate the fleece to individual fibres to create consistency while removing any foreign objects still embedded within the alpaca fleece. The Picker consists of a converyer belt, a licker drum containing within it many tiny metal teeth that grab the fleece off the converyer belt, and a large opener drum that is embedded with large metal spikes which lift the fleece out of the teeth on the licker drum. As the fleece leaves the Picker, it is thrown into a small chamber where conditioners (binder—mineral oil/anti-static agent) were applied to the fibres at a rate of 4% of the weight of the fibre being processed. The conditioners protect static charge, soften the fibres and strengthen bonds between individual fibres which improves processing the fibre to rovings and yarn.

Figure 3. Tumbler for alpaca processing
After the Tumbler operation, the samples A and C went directly to the De-hairer (Figure 4 and Figure 5) while the samples B and D were put back through the Tumbler and Picker an additional two times before going on to the De-hairer. The De-hairer, also referred to as the Fibre Separator, consists of five drums of different sizes with varying sizes of metal teeth. The first two drums, known as the lickers, are 5.08 cm in diameter with many long sharp metal teeth. These drums flatten and align the fibres as they lift them off the conveyor belt. The next three drums use centrifugal motion to separate stiff fibres from the soft pliable alpaca fibres. The alpaca fibres come out the back of the De-hairer where the Doffer combs them off to the final drum creating a fluffy web. In the meantime, the unwanted guard hair and foreign particles are discarded into a waste bin underneath the centre of the machine. More pictures of machines are given in Appendix A.
After going through the De-hairer, the alpaca fibres are in a loose fluffy batting; this batting is weighed and spread out in equal sections on the conveyer belt of the carder (Figure 7).
The Carder uses a sequence of 14 drums to preferentially select and align the finer, premium quality fibres while discarding the lower quality ones. As the fibres leave the Carder they can be manipulated into either a roving or batting.

![Figure 7 Carder for alpaca fibre processing](image)

The Spinning experiment was conducted at Twisted Sisters and Company Fibre Mill (TSM) after the roving was made at the U of S with research fibre. It is the last step of fibre processing before the production of textiles and other materials. Yarns were made during the spinning process from the roving.

**Results**
The fibre samples were weighed after each step of mechanical processing to determine the mass lost and retained. The recorded weights were analyzed to determine the percentage of initial mass retained for each sample at every step within their processing sequence shown in Table 1 and 2.
Table 1. Weight retention of Samples A and C during mechanical processing (% of initial weight retained)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Tumbler</th>
<th>Picker</th>
<th>De-hairer</th>
<th>Carder</th>
</tr>
</thead>
<tbody>
<tr>
<td>A*</td>
<td>97.85</td>
<td>95.85</td>
<td>94.2</td>
<td>93.9</td>
</tr>
<tr>
<td>C**</td>
<td>96.06</td>
<td>94.2</td>
<td>92.38</td>
<td>91.65</td>
</tr>
</tbody>
</table>

* Tide washed fibre  
**Sunlight washed fibre

Table 1. Weight retention of samples B and D during mechanical processing (% of initial weight retained)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Tumbler</th>
<th>Picker</th>
<th>Tumbler</th>
<th>Picker</th>
<th>Tumbler</th>
<th>Picker</th>
<th>De-hairer</th>
<th>Carder</th>
</tr>
</thead>
<tbody>
<tr>
<td>B***</td>
<td>98.37</td>
<td>96.06</td>
<td>95.52</td>
<td>94.28</td>
<td>93.88</td>
<td>92.76</td>
<td>91.58</td>
<td>90.92</td>
</tr>
<tr>
<td>D****</td>
<td>97.45</td>
<td>96.4</td>
<td>95.05</td>
<td>94.4</td>
<td>94.15</td>
<td>93.45</td>
<td>92.75</td>
<td>92.35</td>
</tr>
</tbody>
</table>

*** Purex washed fibre  
**** BabySoft washed fibre

Analysis of the results shown above (Tables 1 and 2), found that a small amount of the initial bulk weight of the fibre samples was removed during processing. The sample that appears to have lost the most significant amount of bulk weight was sample B that retained only 90.92% of its initial weight. This is assumed to be due to the fact that the fibre had more foreign substance and the fleece was more entangled. This was removed from the sample during the three tumbling sessions. In contrast, Sample A retained the greatest amount of fibre, with a final weight of 93.9% of the original. This increase in the amount of retained fibre could be attributed to less entanglement, less vegetation and less oily substance. It also indicated that fibre washed with Tide detergent had less entanglement. Samples C and D, were found to retain a comparatively higher percentage than B of their initial weights after processing. It was found that the fibre sample A retained the greatest amount of its initial weight. The retention differences between the two selected processing sequences imply that the increased processing through the Tumbler and Picker resulted in very little change in the final quantity of the mass.
4.3.1. Fibre Opening and Carding.
The fibre opening starts the actual mechanical processing for the fibre. It is the first stage of the milling operations. Some fibre is separated by hand especially for very large fibre masses that are joined together during the period of drying. The separation by hand reduces the stress on the fibre for the fibre opening machine. The opening machine plays an important role in opening and cleaning the fibre. It was observed that dirt and foreign materials present in the fibres were removed during the opening and carding process. It was also observed that the carding process removed more impurities and converted the fibre into carded sliver (soft, weak rope of fibre).

One of the challenges faced during the experiments with the carding process was the breakage of the carded fibre. Some of the second cut fibre created enormous problems during the carding process. Elimination of second cut fibre and blending of other crimped natural fibre such as silk, bamboo, or flax with alpaca fibre improved the carding process.

During opening and carding, combing of the fibre helped to further remove unwanted materials. It separated the fibres of various lengths by removing very short fibres including the second cuts, and fibres that were joined together. Fibres below 15 mm in length are usually considered short fibres and were removed by the combing process. This was facilitated by the modification of the teeth in the opener and carder.

The research team had an opportunity to look at a few protein (animal) and cellulose (plant) fibre processing equipment in Canada, China, Germany and USA and to discuss with plant operators the challenges and potential improvements to the processing systems. Based on the experience and understanding of fibre processing, the U of S fibre processing team mechanically modified the equipment’s operating parameters to remove shorter and longer fibre. It was also observed that detergents and drying methods had an impact on fibre opening and the finished roving. The quality of the roving in terms of binding, strength, processing time, and visual qualities was dependent on the storage, washing and drying mechanisms.
It was observed that a few detergents like Tide, Cheer, Sunlight, and Baby Soft combined with the dehumidifying drying process had positive impacts on product quality with respect to color, glossiness, strength, entanglement etc. on roving and spinning.

The Spinning experiment was conducted at TSM. The process involved the use of machines to draw the fat roving into thin roving filaments in a continuous format. It was found that Tide detergent washed roving had a good drawing capacity. The thin fibre bundle was further passed into another machine that further increased the thinness of the roving into thread like size with action of torsion working on it to prevent breakage. Yarns were either plied or left as single ply before they were packaged. It was also observed that some yarn products were better compared to others in terms of roving breakage and development of stickiness in the spinning roller. This was due to the cleanness of the fibre and detergents used, non-uniformity of the fibre quality (in terms of second cuts, variations in diameter, and staple lengths) excess usage of binder and anti-static agent.

It was observed that use of anti-static agent and binder to keep the roving intact for yarn manufacturing was necessary; however, excess usage of anti-static agent and binder (4%) created a sticky coating on the surface of the rubber roller of the spinning and yarn machine. A similar observation was also made during roving manufacturing at the University of Saskatchewan with 4 % usage of binder and anti static agent. This stickiness was controlled at the roving stage by reducing the amount of anti-static agent to 1-2% of the weight of the sample size.

5. Conclusions
Alpaca fleece washed with consumer detergents combined with the de-humidification drying enhanced the fibre processing with respect to opening, carding, and spinning and improved the quality of the roving and yarn in terms of color, glossiness, and strength. It was also found that repeating tumbling and picking two to three times produced a clean fibre and improved quality roving and reduced the wastage (<10%). Utilization of anti-static agent and binder kept the roving intact for yarn manufacturing; however, it was
observed in TSM plant while processing the roving to yarn, excess usage of anti-static agent and binder (4%) created a sticky coating on the surface of the rubber roller of the spinning and yarn machine which affected efficiency of the machine. It is important to maintain a small quantity of the anti-static / binding agent 1-2% of the weight of the fibre during processing.

The successful processing of alpaca fibre is crucial for the sustainability of the alpaca industry in Canada. The challenges faced by the alpaca producers are partly due to a shortage of commercial alpaca fibre processing facilities and knowledge of better processing methods.
6. References
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Appendix A

Figure A1: Alpaca Fibre Processing
Figure A2: Alpaca Fibre Processing